CLAIMS

We Claim:

1. A thermal expansion clamping unit for bonding laminae together, comprising:

a base plate;

a top plate;

at least one engager positioned between the base plate and top plate; and

at least one spring functionally associated with the unit.

2. The unit according to claim 1 where the at least one spring is positioned between the base plate and the at least one engager.

3. The unit according to claim 2 where the at least one spring is preloaded prior to bonding.

4. The unit according to claim 3 further comprising a load stage positioned between the at least one engager and the at least one spring.

5. The unit according to claim 4 further comprising at least one adjustable fastener retaining the at least one spring and the load stage against the base plate.

6. The unit according to claim 1 where the at least one engager is an expansion cylinder.

7. The unit according to claim 1 where the at least one engager block is a fluid expander.

8. The unit according to claim 7 where the fluid expander comprises a bellows filled with a gas or liquid.

9. The unit according to claim 1 further comprising a first platen positioned between the base plate and the engager, the first platen being adjacent to an upper surface of a laminae to be bonded.

10. The unit according to claim 9 further comprising a second platen positioned between the base plate and the engager, the second platen being adjacent to a lower surface of a laminae to be bonded.

11. The unit according to claim 10 where the first platen and second platen are made from graphite or a ceramic material.

12. The unit according to claim 1 where the top plate and bottom plate are made from a ceramic material and the engager is made from metal.

13. The unit according to claim 1 where the top plate comprises at least one adjustable set screw positioned above the at least one engager, the set screw being adjustably raised or lowered to define an initial gap setting.

14. The unit according to claim 13 where the at least one engager comprises plural engagers, wherein an at least one adjustable set screw is positioned above each of the plural engagers.

15. The unit according to claim 1 where the at least one engager comprises at least five engagers.

16. The unit according to claim 1 where the at least one engager comprises at least seven engagers.

17. A method for bonding laminae together to form a device, comprising:

providing a thermally assisted bonding unit having at least one pressure regulating spring; and

bonding laminae together using the device.

18. The method according to claim 17 where bonding comprises continuously bonding workpieces using plural, thermally assisted bonding units.

19. The method according to claim 17 further comprising using a conveyorized furnace for applying heat to laminae functionally associated with the bonding unit.

20. The method according to claim 17 further comprising forced convective heating of the laminae, forced convective cooling of the laminae or both, using a gas.

21. The method according to claim 20 where the gas is an inert gas.

22. The method of claim 20 where the gas is contained in the unit.

23. The method according to claim 17 further comprising thermally registering plural lamina using a registration fixture prior to bonding laminae.

24. The method according to claim 23 where the registration fixture includes flexible laminae engagement portions that flex when displaced by expanding laminae.

25. The method according to claim 24 where at least one lamina in a stack includes a thermal registration element.

26. The method according to claim 25 where the registration element is integral with the lamina.

27. The method according to claim 26 where integral with the lamina comprises embedded in the lamina.

28. The method according to claim 25 where plural laminae include registration elements.

29. The method according to claim 17 where the thermally assisted bonding unit further includes a bottom plate, a top plate and at least one engager positioned between the bottom plate and the top plate.

30. The method according to claim 29 where the at least one pressure regulating spring is positioned between the bottom plate and the at least one engager and laminae is positioned between the at least one pressure regulating spring and the at least one engager.

31. The method according to claim 30 where bonding laminae comprises applying bonding pressure stored in the at least one spring to laminae.

32. The method according to claim 30 where bonding laminae comprises heating the thermally assisted bonding unit, the heat causing the engager to expand relative to the top plate and bottom plate such that at a given time after heating, the engager engages both the top plate and laminae.

33. The method according to claim 32 where at the time the engager engages both the top plate and laminae, final bonding pressure stored in the at least one spring is applied to laminae.

34. The method of claim 17 where bonding laminae comprises prebonding a first stack of at least two laminae and prebonding a second stack of at least two laminae, the first stack and the second stack being subsequently bonded together.

35. A method for bonding laminae together to form a device, comprising:
providing a thermally assisted bonding device;
functionally associating laminae with the device; and

continuously bonding laminae together using the device and a conveyorized heating system.

36. The method according to claim 35 where bonding comprises forced convective heating, cooling or both.

37. The method according to claim 36 where convective heating and/or cooling is accomplished using forced inert gas flush.

38. The method according to claim 35 where functionally associating comprises stacking and registering the laminae on the device.

39. The method according to claim 38 where registering comprises thermally assisted registration.

40. The method according to claim 39 where thermally assisted registration comprises a registration device or lamina having a compliant registration element.

41. A thermal expansion bonding fixture for bonding laminae together to form a device, comprising:

a base plate;

a cylinder mounting plate having plural expansion cylinders; and

a pressure distribution plate positioned between the base plate and the cylinder mounting plate.

42. The fixture according to claim 41 having expansion cylinders of different lengths for differential application of pressure to a workpiece.

43. The fixture according to claim 41 including expansion cylinders made from materials having different coefficients of thermal expansion.

44. The fixture according to claim 41 further comprising spring biased expansion cylinders.

45. The fixture according to claim 44 having plural spring-biased expansion cylinders, at least a first cylinder and a second cylinder having different spring constants.

46. The fixture according to claim 41 wherein the base plate, cylinder plate and pressure distribution plate are made from a ceramic material, and the expansion cylinders are made from a metal.

47. A thermal expansion bonding device for bonding laminae together, comprising:

a frame having a base plate, at least two upright arms and an open top; and

an engager positioned within the frame;

wherein pressure exerted on the arms via thermal expansion of the engager is decomposed into a horizontal pressure component and a vertical pressure component.

48. The device according to claim 47 wherein only the vertical pressure component is transferred to the laminae.

49. A registration device for registering laminae, comprising:

a flexible compliant feature; and

a bonding fixture;

wherein during thermal expansion of the laminae the flexible compliant feature flexes against the laminae or bonding fixture.

50. The device according to claim 49 where the flexible compliant feature is removably attached to or integral with the bonding fixture and during thermal expansion of the laminae the flexible compliant feature flexes against the laminae.

51. The device according to claim 49 where the flexible compliant feature is integrated with the laminae and during thermal expansion of the laminae the flexible compliant feature flexes against the bonding fixture.

52. The device according to claim 51 where the flexible compliant feature is embedded in the laminae.

53. A method for registering laminae, comprising:

providing a registration device having a flexible compliant feature and a bonding fixture; and

registering the laminae using the flexible compliant feature;

wherein during thermal expansion of the laminae the flexible compliant feature flexes against the laminae or bonding fixture.

54. The method of claim 53 where the flexible compliant feature is removably attached to or integral with the bonding fixture and during thermal expansion of the laminae the flexible compliant feature flexes against the laminae.

55. The method of claim 53 where the flexible compliant feature is integral with the laminae and during thermal expansion of the laminae the flexible compliant feature flexes against the bonding fixture.

56. The method of claim 55 where the flexible compliant feature is embedded in the laminae.

57. A method for manufacturing a MECS device, comprising:

forming a plurality of intermettalic laminae;

registering the plurality of laminae using integral compliant features; and

bonding the plurality of laminae together using a thermally assisted bonding device having a pressure regulating spring.

58. A solder paste method for bonding laminae together to define a MECS device, comprising:

providing laminae to be bonded that do not include a solder mask;

microetching at least a portion of at least one lamina in a bonding region selected to receive solder paste;

applying solder paste to a microetched portion; and

bonding laminae using the solder paste.

59. The method of claim 58 where laminae comprises at least one spacer lamina.

60. The method of claim 58 where microetching comprises plasma etching, chemical etching or corona oxidation.

61. A method for making a microlaminated device, comprising:

bonding a first stack of laminae using a thermal expansion bonding unit;

bonding a second stack of laminae using solder paste techniques; and

bonding the first stack of laminae to the second stack of laminae to form a third stack of laminae.

62. The method of claim 61 further comprising registering the first stack of laminae using a compliant feature.

63. The method of claim 62 further comprising prebonding at least two lamina of the first stack of laminae or prebonding at least two lamina of the second stack of laminae.

64. The method of claim 63 further comprising forced convective heating of the laminae, forced convective cooling of the laminae or both, using a gas.

65. A thermal expansion clamping unit for bonding laminae together, comprising:

a frame having a base plate, a top plate and support rods positioned between the base plate and the top plate, the support rods coupling the top plate and bottom plate;

at least one engager positioned between the base plate and top plate;

a first platen and a second platen positioned between the at least one engager and the bottom plate, the first platen contacting an upper surface of the laminae and the second platen contacting a lower surface of the laminae;

a load stage positioned between the second platen and the bottom plate;

a spring positioned between the load stage and the bottom plate;

a fastener compressively retaining the load stage and the spring to the bottom plate, the spring storing a compressive force; and

a gap height adjustment screw coupled to the top plate, a space between the gap height adjustment screw and the at least one engager defining a gap;

wherein the at least one engager expands during a heating of the unit such that a height of the gap decreases, wherein when the height of the gap is zero, the compressive force is applied to the laminae.